obtainable. But from the data collected it is evident that widely differing systems of administration prevail.

Table II. does not contain the names of all the colleges and universities in the United States and Canada which pay $45,000 or over in salaries annually to their instructing staffs, because some such institutions did not answer inquiries of the foundation, or return answers in a form available for statistical purposes. The table contains the names of one hundred and three colleges and universities in the United States and Canada which have given specific information that their total payments in instructing salaries exceed $45,000 annually.[10a]

THE TEACHING OF MATHEMATICS TO ENGINEERING STUDENTS IN FOREIGN COUNTRIES[1]

YOUR committee has asked me to speak of the teaching of mathematics in foreign engineering colleges. My remarks will have reference almost exclusively to the German colleges and schools, partly because I am most familiar with the conditions existing in Germany and partly on account of the rather instructive campaign for reforming the whole teaching of mathematics, recently inaugurated in Germany.

As regards other countries I will only say that the situation in England and Scotland where, during the last quarter of a century, technical education has rapidly developed on quite characteristic and individual lines, deserves careful attention. But I am not sufficiently well acquainted with the facts to discuss this educational movement. In France, it is well known that the theoretical training given to engineers is on a very high level, higher even than in Germany, I believe. Thus, the requirements for admission to the École Polytechnique, or even to the École Centrale, include in mathematics almost as much as our engineering students get in their college course. On the top of this preparation, the student receives in the École Polytechnique an excellent two years' course in higher analysis and theoretical mechanics, and then only is he allowed to enter upon his special technical work. It must also be taken into account that admission to the École Polytechnique is by competitive examinations held throughout France, so that this institution, receiving as it does the pick of students from the whole country, can maintain a high level of theoretical excellency. The École des Ponts et Chaussées and the École des Mines to which the student passes from the École Polytechnique, are thus what we might call graduate schools of the highest rank.

Turning now to the German engineering colleges, a comparison with our own best engineering colleges shows apparently but little difference, both as regards requirements for admission and as to the schedule of courses offered in the schools themselves. Nevertheless, I believe that the scientific standard is decidedly higher in the German than in the American engineering college. I am not here concerned with the question whether such a high standard of theoretical knowledge is essential, or even desirable, for the engineer; I merely state the fact. Moreover, it is quite possible that ultimately the average German engineer knows no more mathematics than the average American engineer. All I wish to maintain is that, in my opinion, an able German student, in his Technische Hochschule, or engineering university, can gain a more thorough scientific equipment than an equally able American student in his alma mater.

[10a] The data for instructors and assistants are not reproduced.—ED.

[1] Read before Sections A and D, American Association for the Advancement of Science, and the Chicago Section of the American Mathematical Society, Chicago meeting, December 30, 1907.

The mathematical requirements for admission are about the same in Germany as with us: algebra, geometry, trigonometry. Not a few students now enter the German engineering college with some knowledge of analytic geometry and even of calculus, but many still come without this knowledge. The important point is that the preparatory training in mathematics (including arithmetic) is distributed systematically and continuously over a period of nine years. The same is true of other preparatory studies. It is obviously quite impossible to attain in a four-year high-school course the results attained in the nine-year course of a German Gymnasium, Realgymnasium, or Oberrealschule. This difference in preparation must always be kept in mind in making comparisons between German and American universities.

The mathematical courses offered in the German engineering colleges and required for a degree cover plane and solid analytic geometry, differential and integral calculus and differential equations—*i. e.*, about the same subjects that are required in this country. The subject of theoretical mechanics, which is treated rather differently in different schools, and even in the same school for different degrees, I shall here leave out of consideration, for the sake of simplicity. The amount of time devoted to the higher mathematics, not including mechanics, appears roughly from the following table, in which the first figure in each case gives the number of hours per week devoted to lectures, the second the number of hours devoted to "exercises." These exercises are a comparatively recent innovation. In my time the student had nothing but lectures; to gain a working knowledge of the subject he had to take a text-book and work for himself. Even now, these exercises are optional; they probably exist everywhere, although the table may not show them. There are no periodic examinations such as we have at the end of each semester; but most students take at the end of their course the Staatsexamen, or if particularly ambitious, the Diplomexamen. The lectures in mathematics are rather more advanced and more complete than those in our engineering colleges. But the requirements in the final examinations are not very high.

	First Semester	Second Semester	Third Semester	Fourth Semester	Total
Karlsruhe.....	6+2	6+2	3	2	17+4
Stuttgart.....	7+3	6+4	3+1	.....	16+8
Munich.....	6+3	6+2	5+2	2+2	19+9
Hannover.....	8+1	6+2	.....	.....	14+3
Danzig.....	6	5	4+1	3+1	18+2
Braunschweig...	8+2	6+2	2	.....	16+4
Zürich	8+4	8+4	4+1	.....	20+9

In addition to the more thorough preparation of the German student and to the somewhat higher standard of the lectures on pure mathematics, and largely owing to these circumstances, the treatment of applied mathematics is, I believe, on a higher level in Germany than in this country. The student is better prepared; no time is lost in "recitations," *i. e.*, in trying to find out whether the student has committed things to memory; the professor is thus enabled to treat scientific questions scientifically. Besides, on an average, the German professor of an engineering subject has himself a higher degree of scientific training and is more interested in the mathematical, and in general the scientific, aspects of his subject than his American colleague.

It is of course always hazardous and, moreover, of little use to make such general statements and comparisons; and I do not wish to attach any great importance to them. Neither the German nor the American engineering college is as good as it might be or should be; no institution ever is; an institution is good only in so

far as it is continually changing, developing, rising. The above comparisons are, therefore, given merely as a basis for better understanding the efforts that are now made in Germany for the improvement of mathematical teaching in all its phases. To these efforts I wish to call your special attention.

The German movement for the reform of the teaching of mathematics is of a somewhat complex nature; at least three different movements may be distinguished. One of these, originating with the German association of engineers (Verein deutscher Ingenieure) had as its direct object the improvement of the mathematical instruction in the engineering colleges, with a view to making the instruction less abstract and theoretical and more practically useful to the engineer. To a certain extent, this object has been attained. Practical exercises for acquiring a working knowledge of mathematics have been introduced everywhere, and the lectures on pure mathematics have become less theoretical. Some of the originators of this movement, especially Professor Riedler, of the Charlottenburg College, went so far as to demand that in engineering colleges mathematics should be taught by engineers. Whether or not this was meant as more than a threat I do not undertake to say; certainly, as far as my knowledge goes, no attempt has ever been made in a German engineering college to put the teaching of mathematics in the hands of any one but a trained mathematician. But I believe that in the selection of men for such positions more attention has been paid in recent years to the qualifications of the aspirants; mathematicians with a bent towards applied science being given the preference for positions in engineering colleges.

The second of the three movements referred to above has for its object the reform of the teaching of mathematics in the universities. It is the oldest of these movements, and has borne fruit in a variety of ways. But I can here only advert to it very briefly. The tremendous creative mathematical activity that characterized the last three quarters of the nineteenth century in Germany led to a condition in the universities that was injurious to the preparation of teachers for the secondary schools (Gymnasium, Realgymnasium, Oberrealschule). Too much stress was laid on leading the student as fast as possible to original research in some special line. The system has been described as a system, not of double entry, but of double forgetting; upon entering the university the students, most of whom are fitting for teaching in the secondary schools, are made to forget and almost despise the more elementary mathematics, and when beginning their professional teaching career they are again compelled to forget as fast as possible all the higher and highest mathematics to which they had devoted most of their time at the university. The remarkable development of mathematical activity in our country during the last fifteen or twenty years may bring about a similar situation. Fortunately, the leaders of American mathematics are well aware of the danger of losing the healthy contact with the more elementary mathematics and with applied science. Of course, it is, and always will be, the chief object of a real university to foster original research and productive scholarship. But it is well even for the most advanced specialist not to burn the bridges behind him, but to keep in mind the connection of his specialty with the foundations of knowledge, on the one hand, and with kindred branches of science on the other. As Sir Isaac Newton expressed it in his quaint way in a letter to Dr. Lord: "He that in ye mine of knowledge deepest diggeth, hath, like every other miner, ye

least breathing time, and must sometimes at least come to terr, alt for air.''

The desire to make the university teaching of mathematics more practically useful and bring it into live contact, as far as possible, with the whole tendency of modern scientific thought led, on the one hand, to a strengthening of all branches of applied mathematics, not only by courses offered in the universities, but also by such publications as the Encyklopädie, which includes applied mathematics in the widest application of the term; on the other, it led to reforms in the courses offered to future teachers of mathematics, and ultimately to a thorough investigation of the teaching of elementary mathematics in the secondary schools of Germany.

The improvement of the teaching of elementary mathematics is the aim of the third and most recent mathematical reform movement in Germany. The reforms proposed in this connection by the committee of the German Association of Naturforscher und Aerzte, at the Meran meeting, in 1905, appear to me to deserve very careful consideration. They would apply, in this country, to the teaching of mathematics not only in the high schools, but just as much in the engineering colleges. For, with the preparation that our students actually have, I am convinced that the best method of imparting a good working knowledge of the elements of analytic geometry and calculus is not through lectures, but through actual teaching based mainly on solving problems, that is, by the methods not of the German university, but of the German secondary school.

The proposals of the committee[2] do not change very essentially the number of hours required for mathematics. These are to be: in the Gymnasium as well as in the Realgymnasium, four hours per week in each of the nine years; in the Oberrealschule generally four hours per week, in the third and fourth years six hours. The first three years are devoted to common arithmetic and intuitional geometry, the next three years to algebra and geometry carried along together, the last three years to advanced algebra, trigonometry, advanced geometry, conic sections (treated synthetically and analytically) and, in the Oberrealschule, the elements of the calculus. Apart from matters of detail this distribution does not vary very much from the practise now followed in the best Prussian schools.

While thus the general program can not be said to constitute a radical departure from existing conditions, the statement of what should be the principal aim of mathematical teaching and the indications given for carrying out this aim throughout the whole course[3] appear to me as the most important features of the report. In addition to the well-recognized object of mathematical teaching to train the mind in rigorous logical reasoning the report insists particularly on the training of geometrical intuition and on acquiring the habit of functional thinking. The carefully prepared explanations accompanying the detailed program for the nine-year course show how these aims should guide the instruction at every step. The insistence on the idea of the functional relation can not be recommended too strongly to our writers of college text-books, from trigonometry to differential equations. But, as this report demands, it should even enter into the very elements of algebra and geometry.

It should be observed that the committee that prepared this report was not composed of mathematicians only; all branches of science taught in the secondary schools were represented in it; and all these branches received equally careful attention. While the portion of the report devoted

[2] See *Zeitschrift für mathematischen und naturwissenschaftlichen Unterricht*, Vol. 36 (1905), pp. 533–580.

[3] *Loc. cit.*, pp. 543–545, 550–553.

to mathematics covers almost the whole range of the subject, from arithmetic to the elements of the calculus, required of our engineering students, there is nowhere any reference to students of engineering or to any other special class of students. I might, therefore, appear out of order in speaking of this report at the present occasion. But I wish to say most emphatically that, in my opinion, there is no special "mathematics for engineers"; nor is there any method of teaching mathematics, specially adapted to engineering students. If it is wrong to present mathematics in a form so abstract as to make it unintelligible to the student, it is just as wrong to present the results of mathematics in a form so concrete as to reduce the science to a mere art of performing certain mechanical operations, to make it, as the saying goes, a mere tool, and not a habit of thinking.

In conclusion allow me to say that I should be the last to advocate a remodeling of our institutions of learning on the German plan, or the French plan, or any other existing plan. But I believe that the time has come in this country when one or two years of general college study can be demanded as preparation for the professional engineering course, at least for those more able students who wish to obtain a thoroughly scientific preparation for their professional career. An opportunity should then be offered to students of engineering of scientific ability to extend their knowledge on the theoretical side.

ALEXANDER ZIWET
UNIVERSITY OF MICHIGAN

THE BRITISH BUREAU OF SLEEPING SICKNESS

THE British Colonial Office has issued the following statement:

At the instance of the late secretary of state for the colonies and with the cooperation of the government of the Sudan and the Royal Society, his majesty's government have decided to establish in London a bureau for the collection and general distribution of information with regard to sleeping sickness. The Royal Society will find accommodation for the bureau at Burlington House, and one fourth of the cost of up-keep will be borne by the Sudan government.

The bureau will be under the general control and direction of an honorary committee of management, appointed by and responsible to the secretary of state for the colonies. The committee will be composed of the following: Chairman, the Right Honorable Sir J. West-Ridgeway, G.C.B., who is also chairman of the advisory committee of the tropical diseases research fund; Sir Patrick Manson, M.D., K.C.M.G., F.R.S.; Sir Rubert Boyce, F.R.S.; Dr. Rose Bradford, F.R.S. (representing the Royal Society); Colonel D. Bruce, C.B., F.R.S.; Mr. E. A. Walrond Clarke (representing the foreign office); Mr. H. J. Read, C.M.G. (representing the colonial office), with Mr. R. Popham Lobb, of the colonial office, as secretary.

The main function of the bureau, which will be administered by a paid director, will be to collect from all sources information regarding sleeping sickness, to collate, condense, and, where necessary, translate this information, and to distribute it as widely and quickly as possible among those who are engaged in combating the disease. The publications of the bureau will be divided into two categories, viz., scientific publications intended for those who are engaged in research work or in carrying out medical administration in the infected districts, and publications of a less technical character for the use of government officials, missionaries and others, whose duties involve residence in those districts. One important piece of work will be the preparation of a map of the whole of tropical Africa, showing the distribution of the disease and of the different species of blood-sucking insects which are suspected of conveying it. A map of this kind showing, as it would, the extent to which the distribution of the disease coincides with the distribution of the different